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OF OUTER SPACE

HIGHLIGHTS IN SPACE TECHNOLOGY AND APPLICATIONS OF 1989

Report submitted by the International Astronautical Federation

Note by the Secretariat

Annexed is a report on the highlights in space technology and applications of 1989 submitted by the International Astronautical Federation (IAF) in accordance with the request of the Scientific and Technical Sub-Committee for the submission of annual reports by IAF on scientific and technological developments in the exploration and peaceful uses of outer space. The report is being circulated, as received, only in the language of its submission (English).

Annex

HIGHLIGHTS IN

SPACE TECHNOLOGY AND APPLICATIONS

1989

A report submitted by the International Astronautical Federation (IAF) in accordance with the request of the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, United Nations, for the annual submission of reports on technical developments in the exploration and other peaceful uses of outer space.

Submitted in English.

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1 December 1989

HIGHLIGHTS IN

SPACE TECHNOLOGY AND APPLICATIONS

1989

Prepared by the

INTERNATIONAL ASTRONAUTICAL FEDERATION (IAF)

for the

Scientific and Technical Subcommittee
Committee on the Peaceful Uses of Outer Space
UNITED NATIONS

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I. SUMMARY

The highlights of 1989 in space technology and applications were the consolidation of space transportation capabilities worldwide; the resurgence of satellite communications as a consequence of new service opportunities; the entry of socialist countries into the global commercial space marketplace; a virtual rebirth in space science and exploration; recasting of plans for space stations, future space exploration missions, and advanced launch vehicles; and expansion of the potential role of space in addressing global environmental issues.

Maturity of space transportation systems was reflected in the repeated successes of the new Ariane 4 family and the redesigned U.S. space Shuttle, both of which had seen their first launches in 1988. The Soviet family of launchers, led by the Proton, continued their long record of service in both manned and unmanned launches; the newest member of that family, the Buran space shuttle with its Energiya launcher, debuted in November 1988. New vehicles flown successfully to orbit in 1989 included the U.S. Titan 4 and several versions of the Ariane-4 series. 1989 also saw the first U.S. commercial launch to orbit, of the British Marcopolo 1 broadcast satellite, by a McDonnell Douglas Delta.

Both the Soviet Union and China entered the commercial space transportation market, with China winning a competition for launching two Australian Aussat communication satellites and the Soviet Union offering its full line of operational launchers to foreign customers.

In satellite communications, the drought of the past few years was ended with a number of launches and new projects, many of which incorporated significantly advanced technologies. The challenge of fiber-optic ground cables is being met by a host of new satellite service capabilities, led by services to mobile ground stations (e.g., ships, aircraft, trucks, etc.), direct-broadcast audio and video transmission, and closed-circuit business traffic.

Spectacular data were returned from the U.S. Voyager's Neptune/Triton flyby, and significant new scientific spacecraft launched in 1989 include the Magellan radar orbiter to Venus, the Galileo orbiter and probe to Jupiter and its moons, the Cosmic Background Explorer, and the Hipparcos star-mapper. Plans for further planetary exploration by robot spacecraft have been extended to include sample returns from Phobos and Mars; study of planetary surfaces via penetrators, ground-based instruments, robot rovers, and balloons; orbiting radar and other surveying techniques; and exploration of one or more comets. Manned programs to the Moon and Mars are under serious consideration.

Space station development accelerated with the addition of a new module to the Soviet Mir station and preparations for another early in 1990. Design modifications to Space Station Freedom, driven by budget pressures, are not expected to delay its initial launch, currently scheduled for 1995.

Advanced launch vehicle development also accelerated, with Europe's Ariane 5 (both with and without the Hermes manned vehicle), the U.S. Advanced Launch System, Japan's H-2 (with and without the HOPE spaceplane), China's Long March 2E and 3A, and

next-generation airbreathing launchers in the U.S. (the National Aerospace Plane), the FRG (Saenger), and Japan (the LACE engine). Prospects for new applications of the Soviet Energiya, both with and without the shuttle Buran, were also explored.

A particularly important development in 1989 was the growth of planned activities for studying and analyzing global environment issues. Several international organizations have made such studies the focus of their International Space Year programs, and a number of nations have initiated their own projects in this area.

II. SPACE TRANSPORTATION

A. Current Launch Activities

(1) Soviet Union

The Soviet Union has offered its extensive fleet of launch vehicles on a commercial basis for launching payloads of other nations and for commercial enterprises. Their fleet includes the following launch vehicles:

(a) Cosmos, a 2-stage vehicle using storable propellants, able to launch 1100-1350 kg to a 400-km orbit or 600-800 kg to a 1600-km orbit. It has flown successfully over 300 times.

(b) Tsyklon, a 3-stage, storable-propellant launcher able to loft 4,000 kg to a 200-km orbit. It has flown successfully over 75 times.

(c) Vostok, a 3-stage vehicle powered by liquid oxygen and kerosene. It has successfully launched over 90 payloads ranging from 4,730 kg into 200-km orbits to 1,840 kg into 650-km orbits.

(d) Soyuz, also a 3-stage vehicle employing oxygen-kerosene

propellants, can launch 7,000 kg into 200-km orbit. It has flown successfully over 560 times.

(e) Molniya, a 4-stage, oxygen-kerosene vehicle, has carried about 190 payloads with mass up to 1,500 kg into highly elliptical orbits with apogee altitudes of 36,000 km.

(f) Proton, with either 3 or 4 stages powered by storable propellants except for the fourth stage, which uses oxygen and kerosene, can launch 21,000 kg to 200-km orbits, over 2,000 kg into geostationary orbit, or the order of 5,000 kg into lunar, Venus, or Mars ascent trajectories.

(g) Zenit, with 13 successful launches a relative newcomer to the Soviet stable, uses either 2 or 3 stages burning oxygen and kerosene, can launch 13,700 kg into a 200-km, 51.6-degree orbit or 1,600 kg into geostationary orbit.

(h) Energiya, first flown successfully in November 1988 when it was used to launch the Buran shuttle vehicle (an earlier flight in May 1987 was only a partial success), can lift 100,000 to 200,000 kg into low Earth orbit. Energiya has been proposed for use in launching large platforms to both low and geostationary orbits, Earth-Moon libration points, and lunar orbits, as well as in establishing outposts and bases on the Moon and Mars. Energiya's next flight, which will test a parachute recovery system for its strap-on boosters, is scheduled for 1990; the next Energiya-boosted Buran flight is expected to occur early in 1991.

(i) Start, a new commercial mobile launcher derived from the SS-20 military launcher (all of whose existing components are

being destroyed under the 1988 Intermediate-Range Nuclear Forces [INF] treaty), is a 3-stage, all-solid-propellant vehicle being developed to carry 140-kg payloads to 500-km low orbits. Its mobile transporter/launcher allows it to be launched from different sites without need for launch pad complexes

(2) United States

The 3-orbiter Space Shuttle fleet has successfully increased its rate of launch since its return to service in September 1988 following the loss of the fourth orbiter Challenger, and is expected to reach full capacity (12 to 14 flights per year) with the advent of Challenger's replacement in 1992. Following the successful redesign of the solid-rocket Shuttle boosters, NASA initiated development of a new Advanced Solid Rocket Motor in 1989, and also continued studies of an alternative Liquid Rocket Booster. A Shuttle-derived cargo vehicle called Shuttle-C, able to carry about 70,000 kg into low Earth orbit, is also under consideration for interim use until the turn of the century, when development of the new low-cost Advanced Launch System family is expected to be completed. A modification to orbiter Columbia to extend its orbital flight time to about 16 days was approved and will be implemented in 1990; it will be used to carry the Microgravity Science Payload on a 13-day mission in 1992. It is planned to modify a second orbiter for 28-day missions in the early 1990s.

As a result of a U.S. policy change in 1986, which removed commercial payloads from Shuttle manifests, several manufacturers of U.S. launchers initiated vigorous commercial market activity

culminating in September 1989 with the first commercial U.S. space launch: British Satellite Broadcasting's Marcopolo 1, placed into geostationary orbit by a McDonnell Douglas Delta launcher. Three U.S. companies (McDonnell Douglas, General Dynamics, and Martin Marietta) have now received firm orders for about 20 launches (over and above U.S. government launches) through 1993, and three new companies launched suborbital payloads in 1989: Conatech, Space Services Inc. (whose Consort I's 17-minute flight carrying six microgravity payloads marked the first U.S.-licensed commercial launch), and Hercules/OSC (Pegasus). An attempted launch by a fourth company, Amroc, was unsuccessful. Of particular interest because of their implications to growth in international cooperation were the joint agreements Martin Marietta signed with European firms Contraves (Switzerland) and Dornier (FRG) for commercial Titan payload fairings and payload carriers, respectively; General Dynamics' launch insurance agreement with Lloyds (UK) for 15 Atlas vehicles; and Hercules' agreement with Arianespace (France) for marketing of Pegasus in Europe.

Significant 1989 milestones in U.S. launch operations also included the first launch of the new Titan 4 vehicle, launch of the last Titan 34D, launch of the first commercial Titan (orbiting the Japanese JCSAT and British Skynet satellites), launch of the refurbished and updated Titan 2, converted from a military missile to a space launch vehicle, and initiation of development on Taurus, a new all-solid-propellant Standard Small Launch Vehicle which ultimately will be able to launch 1500 kg payloads to 650-km low orbit.

(3) Europe

1989 saw the final flights of Ariane 2 and Ariane 3, and consolidation of the success of the Ariane 4 family, which attained near-monthly successful launches only a year following the first (1988) voyage of this sophisticated new vehicle. The breadth of its capabilities in configurations ranging from a core vehicle alone through various combinations of two to four solid-propellant boosters and two to four liquid-propellant boosters (1,900 to 4,200 kg into geosynchronous transfer orbit) makes it competitive across the board with all current Chinese and U.S. commercial launchers and all Soviet launchers other than Energiya.

A particularly noteworthy event in 1989 was the signing by Arianespace of a U.S. $2.9 billion production order for 50 Ariane-4 shipsets with four European companies: Aerospatiale (France), MBB/Erno (FRG), Matra (France), and SEP (France). Arianespace's backlog of orders for launches extending to 1994 now exceeds U.S. $2.5 billion.

(4) Japan

Japanese space launch activity continued in 1989 with both solid-propellant (M-series) and liquid-propellant (H-1) vehicles, both of which lofted several payloads successfully. NASDA also flight-tested for the second and third times a quarter-scale model of the new H-2 vehicle, currently scheduled for first full-scale flight in 1993. A major step over the current operational H-1, which can launch 550 kg to geostationary orbit, the H-2 will be able to lift a 2,000-kg geostationary-orbit payload, 10,000 kg

to low orbit, or 2,000-3,000 kg to Mars or Venus trajectories. It uses two 160,000-kg-thrust solid-rocket motors to boost the first stage, which is powered by a new 100,000-kg liquid-propellant hydrogen-oxygen engine, the L-7. The H-2's second stage also has a new L-5A restartable hydrogen-oxygen engine derived from the H-1's L-5 powerplant.

(5) China

China outbid European and U.S. launch suppliers for Australia's two Aussat satellites, scheduled for launch in 1991 and 1992. Both will be launched by Long March 2E (CZ-2E) vehicles, pending resolution of a June, 1989 restraint on release of the U.S.-built (Hughes) satellites to China for launching. China also won the competition to launch Asiasat 1, the refurbished Westar 6 recovered in 1984 by Shuttle astronauts. It will be launched by Long March 3 (CZ-3).

The CZ-3 is a 3-stage vehicle able to deliver about 1300 kg to a geosynchronous transfer orbit. China also launched its first polar-orbit weather satellite last year aboard a new launcher, the CZ-4, which can carry about 2,000 kg to the polar orbit. Two new vehicles under development include the CZ-2E, planned for first launch in 1991 and able to boost about 8,000 kg to low Earth orbit, and the CZ-3A, scheduled for 1992 and capable of placing about 2,000 kg into geosynchronous transfer orbit.

(6) India

The second launch of India's new Advanced Space Launch Vehicle (ASLV) was not successful, but the Indian Space Research Organization has made significant progress in the development of a Polar Satellite Launch Vehicle (PSLV), which will be able to

launch Earth-observation satellites into a polar orbit. All propulsion stages have been qualified, including the 60,000-kg-thrust Vikas storable-liquid-propellant engine, a long-duration upper stage, and a large solid-propellant booster. The first PSLV launch is expected by the end of 1990.

(7) Other Launch Vehicle Activity

Israel's first satellite, Offek 1, returned to Earth in January 1989, and Israel plans to launch the 200-kg Offek 2 on its Shavits (Comet) launcher into a retrograde (east-to-west) orbit in January or February 1990. Sweden developed its MAXUS vehicle, able to launch 600 kg to 900 km for about 15 minutes of microgravity flight (scheduled for first launch early in 1990), Pakistan launched a 4-stage rocket to 640 km, and Brazil is in the process of developing an indigenous launcher to support its budding space program.

B. Development Activity

The primary space-transportation development activity in the USSR is an upper stage for the Energiya launch vehicle. In the U.S., besides the abovementioned Advanced Solid Rocket Motor, Extended-Duration Orbiter, and Advanced Launch System, an Orbital Maneuvering Vehicle is being developed by TRW for use with Space Station Freedom (to be flight-tested on the Shuttle in 1993), and technology programs have been initiated on a Space Transfer Vehicle and an Aerobrake Experiment designed to evaluate the use of atmosphere-grazing in place of retrothrust maneuvers. The U.S. and Italy are also cooperating on a space tether experiment, to be flown on the Shuttle in 1991, which has interesting

implications in aiding the transport of payloads to and from space stations.

Europe is actively developing the Ariane 5 launch vehicle which, in combination with the Hermes spaceplane, will become the mainstay of both manned and unmanned space-station servicing activities for Europe in the late 1990s. Ariane 5 will be able to lift a 6,800-kg payload into geosynchronous transfer orbit.

A similar concept on a slightly smaller scale, Japan's HOPE, is in the early research phase. It will use the H-2 launcher to carry a small but, unlike Hermes, unmanned winged reentry vehicle with a payload capacity of 1200 kg, which Japan plans to use both to service the space station and to develop a future hypersonic airbreathing launcher.

Other new launch concepts which utilize atmospheric lift and airbreathing engines for portions of their flight trajectory include the U.S. Aerospace Plane, the British HOTOL, and the German Saenger. All three are in the early prototype development phase (although work on HOTOL was sharply reduced in 1989), and are not likely to see service as space launchers until well beyond the turn of the century. The Soviet Union is also testing aerospace plane designs and evaluating airbreathing scramjet technology for future hypersonic cruise vehicles.

C. Other Transportation Services

In addition to launch services, a number of organizations have begun to provide or develop reentry capsules, primarily for space processing research activity, but also, as the U.S., the Soviet Union, and China have done for years, to

return photographs and other data recorded by their satellites. New commercial entries in this field include General Electric in the U.S., China, the USSR, Italy's CARINA, France's Microlina and Janus, Germany's Raumkurier, Intospace's Cosima, and derivatives of NASA's Lifesat. China has launched and returned microgravity research payloads for Matra (France) and Intospace (FRG), and the USSR has also launched and recovered payloads for Intospace and Payload Systems, Inc.

Several countries also initiated intensive assessments of the viability of creating new space launch facilities, primarily for commercial customers. Prominent among these are Australia, which is exploring the use of Cape York on the northern coast, and the U.S., in which the states of Florida and Hawaii have both conducted extensive feasibility studies of new launch sites. It is still too soon to judge whether or not any of these will proceed to development and construction.

III. UNMANNED EARTH ORBITAL ACTIVITIES

A. Telecommunications

(1) General-Purpose Systems

A major resurgence of satellite communications activity began in 1989, spurred by the growth in both number and capability of small Earth terminals and the major expansion in demand for data services by industries worldwide. Recognition of the need for both national and international communications links in developing countries also accelerated. Highlights in the field this year included the following:

(a) European Spacecraft

o Olympus 1, a multipurpose advanced-technology satellite, which used for the first time the Eurostar bus, the basis for many future satellites.

o Marcopolo 1, the first of two broadcast satellites for British Satellite Broadcasting Ltd.

o Tele-X, Sweden's first domestic communications satellite.

o TV-Sat 2, a direct-broadcast German satellite with five TV broadcast channels to FRG.

(b) New European Programs

o Commitment to Spain's Hispasat, which will provide direct-broadcast TV to Spanish-speaking markets in Spain, the Canary Islands, latin America, and parts of the U.S. The two satellites will be built by Satcom International, a joint venture of Matra (France) and British Aerospace, using the Eurostar bus originally developed for Olympus.

o Eutelsat's order for the Eutelsat 2 series of 5 Ku-band satellites, the first of which will fly in 1990. The Eutelsat 3 series, planned for 1997, will use HDTV.

(c) Asia

o Launch of Japan's JCSAT

o Launch of Japan's broadcast satellite BS-2X

o Launch of Japan's Superbird A, the largest (at 2500 kg) commercial communications satellite to date.

o Launch of India's Insat 1C by Ariane 3, considerably augmenting India's communications services.

o Launch of Arabsat 1C

o Commitment to Asiasat to build and launch Thaisat, a domestic satellite for Thailand and much of Southeast Asia.

(d) United States

o Launch of the second Tracking and Data Relay Satellite (TDRS), completing the minimum operating TDRS System.

(e) International

o Creation of International Satellite Communication, Ltd (INSCOM), a joint venture between the China Great Wall Industry Corporation and Avibras Aeroespacial (Brazil), to provide communication satellite launching, tracking, and networking services.

o Offer to Western and unaligned customers by the Soviet Union for lease of transponders on the Gorizont communication satellite system through Intersputnik. The Soviet Union also announced its intention to develop a new generation of 21-transponder C/Ku-band communications satellites nicknamed "Glavstar," aimed primarily at Western customers.

o Creation of joint ventures by Matra (France) and British Aerospace (UK) for marketing of satellites using the Eurostar bus (Satcom International), and by GE (U.S.) and Selenia (Italy) to build and market communications satellites worldwide.

o Launch of two Intelsat V satellites, contracts signed for Intelsat VI launches, and contracts signed for Intelsat VII.

o Signing of Nepal as Intelsat's 116th member.

o Receipt by Turkey of proposals for two domestic Ku-band satellites to be launched in 1993.

o Signing of a 5-nation treaty (Peru, Ecuador, Colombia, Venezuela, and Bolivia) supporting Project Condor, a system of two 24-transponder satellites to be launched in 1993 or 1994.

(2) Mobile Systems

(a) Telesat Canada and the American Mobile Satellite Company signed an agreement for the first two Western-Hemisphere mobile communications satellites.

(b) Inmarsat signed a contract with a joint-venture company, GE (U.S.) and Marconi (UK) for three to nine second-generation satellites, which will include the capability for aircraft communications.

(3) Navigation and Position Location

(a) The U.S. and the Soviet Union signed an agreement for cooperative aircraft navigation use of their satellite navigation systems (the U.S. Global Positioning System [GPS] and the USSR Global Navigation Satellite System [GLONASS]) through the International Civil Aviation Organization (ICAO).

(b) The first two-way position-location system using small (pocket-size) terminals was introduced by Geostar (U.S.).

(c) The Soviet Union launched Nadegda, equipped both for navigation and for search-and-rescue support in the COSPAS/SARSAT program.

B. Earth Observations

The most significant development in this field in 1989 was recognition of the need for space capabilities in addressing the issues associated with global environmental change. A 26-nation Space Agency Forum for the International Space Year (SAFISY) was created, and "Mission to Planet Earth," a phrase originally coined by former NASA Associate Administrator Burton Edelson and popularized by U.S. astronaut Sally Ride in 1987, was adopted as SAFISY's primary activity for the ISY. It was noted, for example, that the agencies of SAFISY plan to launch a combined total of 48 applicable satellites during the coming decade, and that coordination of their activities is an essential element in a global program.

Several international organizations, including the IAF and the International Council of Scientific Unions (ICSU), have already set up programs to study, monitor, and analyze global change, joining ICSU's existing International Geosphere-Biosphere program, and several countries have also initiated related programs (e.g., the U.S. Global Change Program, organized by the National Academy of Science). This activity has lent some impetus to previous attempts at an international consortium for remote

sensing, comparable to Intelsat and Intersputnik in communications. Indeed, 1989 saw some preliminary discussions between the U.S. National Oceanic and Atmospheric Administration (NOAA), which operates much of the U.S. remote-sensing infrastructure, and France's SpotImage on coordination of data acquisition and analysis.

Major new national efforts in this area are development of the U.S. Earth Observing System for the polar platforms that will be associated with Space Station Freedom, launch of the Soviet Resurs 1 to perform multiscale spectrozonal observations, launch of the European Meteosat and French Spot 2, launch of Japan's weather satellite GMS-4 by an H-1, and implementation of radar-imaging satellites by Canada (whose Radarsat launch was postponed from 1991 to 1994), Japan, and Europe. France is also exploring a radar-equipped satellite with resolution in the 2-50 meter range to complement its Spot spacecraft, for possible launch in 2000-2001. India's first state-of-the-art remote-sensing satellite IRS-1A, launched by Arianespace, is being applied to forest monitoring, potable-water delineation, wasteland mapping, flood, drought, and water-resource management, mineral resource exploration, agriculture monitoring, and agriclimate zoning. The U.S. Landsats 4 and 5, operated by the company Eosat and used by a number of countries which have built ground stations for access to Landsat data, have now been funded by the U.S. through at least 1990 and Landsat 6 is on schedule for launch in 1991.

Building on the long history of remote-sensing satellites in cataloguing major events of global significance (for example, Amazon deforestation, first detected in 1979, the Mt. St. Helens

eruption in the Western U.S. in 1982, the Chernobyl fire in the Soviet Union in 1986, the floods in India in 1988), Landsat and Spot satellites provided detailed information on the Prince William Sound oil spill on the Alaska coast in 1989.

IV. MANNED EARTH ORBITAL ACTIVITIES

A. Space Stations

(1) The Soviet Mir

The Mir space station was vacated by its crew in April due to delays in preparing two new modules that were to be attached to the station. It was reoccupied by two cosmonauts in September, and the first of the two modules, a service unit equipped with manned maneuvering units comparable to those used by U.S. Shuttle astronauts for extravehicular operations, was launched to Mir in October. It's solar panels will double Mir's present capacity to about 25 kW, and it will also double the station's complement of stabilizing gyros from 6 to 12.

The second module, which will have docking ports for the Buran Shuttle, is scheduled for launch in February 1990, and will be ready for the next Buran launch, an unmanned mission to Mir currently scheduled for early 1991. The first manned Buran mission is planned for 1992. With the current fleet of three shuttles the USSR will easily be able to meet the currently planned shuttle launch frequency of one per year, reduced by funding constraints from the original intention of 2 to 4 annually.

The renewed Mir operations also reflected the new commercially oriented approach of the Soviet space program; for

example, the September launch featured advertising by an Italian insurance company, displayed in large letters on the Soyuz launch vehicle for all the world to see on television. An agreement was also initiated between the USSR and Japan to carry a Japanese journalist on a 1991 flight for a sizable fee; she has begun training at the Cosmonaut Training Center near Moscow.

Other international activities related to Mir included an agreement with a U.S. company, Payload Systems Inc., to fly experiments on the Mir, an agreement with the UK for an Anglo-Soviet Juno mission in 1991, and agreement on a 1992 Franco-Soviet mission involving a French spationaut. Discussions are also under way with FRG for participation in a Mir mission by a German cosmonaut.

(2) Space Station Freedom

Development of the station's design continued in 1989, with several changes necessitated by U.S. budget constraints. Agreements were concluded this year between the U.S. and Japan, which expects to invest about U.S. $2 billion in its Japanese Experiment Module and related developments, between the U.S. and the European Space Agency, which has committed about U.S. $4.5 billion to the various Columbus space-station projects, and between the U.S. and Canada, whose remote servicing system will be developed by Canada at a cost of U.S. $1.2 billion. Sweden became the tenth country to join ESA's Columbus program, with a 1% share.

Operations planning for Freedom was begun this year. 27 flight experiments and concept studies were selected for the

station's laboratories, in the disciplines of space physics, solar and planetary physics, exobiology, astrophysics, Earth and environmental science, and communications technology. Work also continued on the Flight Telerobotic Servicer (Martin Marietta, USA), the Orbital Maneuvering Vehicle (TRW, USA), and other station facilities, in addition to the abovementioned elements being developed by Japan, ESA, and Canada. Design definition of the associated U.S. free-flying platforms (both polar and co-orbiting) was also established by GE (USA), and ESA selected a Matra (France) design for the Columbus polar platform, based on the Mark 2 service module being built for the French Spot 4 and Helios platforms. NASA decided to request bids for a Crew Emergency Rescue Vehicle to be initiated in 1992.

B. Life Sciences Research

Research in bioastronautics continued in 1989 on the Soviet Mir space station and on U.S. Shuttle flights, as well as in sounding-rocket flights in a number of countries. A primary focus for future development was the definition and design of laboratory facilities for Space Station Freedom and Mir, and planning biotechnology experiments and facilities needed to define future manned lunar and planetary missions. Integration of humans with automated systems and telerobotic devices is of particular interest in this research. In October 1989 NASA awarded contracts to Lockheed and McDonnell Douglas for design definition of a 2.4-meter centrifuge, one of the primary life-science research facilities on Space Station Freedom.

The Soviet Cosmos 2044 (BION-9), launched in October 1989,

carried live organisms, including two monkeys, into orbit as part of a broadly based international life sciences research program.

In 1989 much emphasis was placed on bioastronautics technologies having applications outside the space program. Tiny biochemical sensors developed by NASA Ames Research Center in the U.S., for example, are designed for implantation in the body to measure in real time the concentrations of ions such as calcium, sodium, and potassium, to study microgravity deconditioning and provide information for the development of countermeasures. These techniques could be extremely useful in clinical medicine and biochemistry on Earth, by replacing the traditional time-consuming and costly method of collecting, storing, and shipping degradable biological samples.

Another example of the application of space-developed techniques was the "telemedicine space bridge" established by NASA and the USSR to relay medical advice and assistance in real time via satellite to doctors in Armenia after the December 1988 earthquake and to doctors tending the victims of a 1989 gas explosion near the Soviet city of Ufa in the Ural Mountains.

Spacelab

Nearly two dozen Spacelab flights are planned through the end of the century. The Space Life Sciences Laboratory is being prepared for launch on the Shuttle in August, 1990. Planning for international Spacelab flights was formalized by a U.S. - FRG agreement on Spacelabs D-2 and D-3, scheduled for the early 1990s. The highly successful D-1 flight in 1985 presages comparable success on these flights. A dedicated Japanese

Spacelab flight has also been scheduled for June, 1991, some of whose experiments will assist in Japan's plans to develop manned spaceflight capability in conjunction with the abovementioned HOPE spaceplane.

V. SPACE EXPLORATION

A. Unmanned Systems

The unquestioned highlight of 1989 in unmanned space exploration was the spectacular U.S. Voyager 2 flyby of the planet Neptune and its moon Triton. Discovery of Neptune's Great Dark Spot, so similar to Jupiter's Great Red Spot, the planet's extremely high atmospheric winds, four wispy rings and six new satellites, and the nitrogen-methane ice eruptions on Triton ranks among the decade's most important events in planetology. It will be ten years before all the data are analyzed, but the results, and the engineering feat of obtaining them so successfully from a 14-year-old spacecraft transmitting a tiny, 20W signal over a distance of 5 billion km, will give Voyager's grand tour of the four outer planets a unique place in the history of space.

1989's first major unmanned exploratory event, however, was not as fortunate. The first of two spacecraft launched in July 1988 by the USSR to explore Mars' moon Phobos had been lost in August 1988 due to an inadvertent signal. In March 1989 the second spacecraft was also lost while in orbit around Mars, prior to its planned 9-10 April examination of Phobos (which was to have been the highlight of the mission), but after having sent several weeks of telemetered data on the planet and its moon.

These data were the first information obtained on Mars since the U.S. Viking Orbiters' transmission was terminated over a decade ago. The next will be the U.S. Mars Observer, currently under construction and scheduled for launch in 1992, followed by three planned (but not yet authorized) Soviet missions: an orbiter in 1994 that may land several small surface instrument stations and an atmosphere-exploring balloon; a 1996 or 1998 launch of a Mars rover vehicle; and a 2001 - 2002 sample return mission that, say the Soviet scientists, will require international cooperation.

In the U.S., the Jet Propulsion Laboratory's Exploration Support Activity has also proposed a second Mars Observer in 1996, two Mars Global Network launches in 1998 to plant 24 penetrator-landers all around Mars, two Mars sample-return missions in 2001 (obvious candidates for Soviet cooperation), a Mars manned-site reconnaissance orbiter and communications orbiter in 2003, three Mars rovers in 2005, 2007, and 2009, and two more sample-return missions with rovers in 2011, to collect the data for a final decision on a manned landing site.

Despite the unfortunate experience of the Phobos spacecraft, 1989 will go down as a banner year for unmanned space exploration. In addition to Voyager's success, the U.S. in May launched a radar mapper, Magellan, to orbit Venus beginning in August 1990, in October Galileo, a Jupiter orbiter and atmospheric probe, and in November the Cosmic Background Explorer. NASA also received authorization to proceed with a comet rendezvous and asteroid flyby (CRAF) mission and Cassini/Huyghens, a joint U.S.-European explorer to Saturn and its moons. These missions will be the first to use a 1500-kg

standard spacecraft bus, the Mariner Mark II, designed specifically for planetary exploration missions. In August, ESA launched Hipparcos, an astronomy satellite designed to map 120,000 stars with unprecedented precision, and although it did not attain its proper geostationary orbit due to failure of its apogee boost motor (sadly, the first failure after 26 successes), it is expected to accomplish a major portion of its mission. The Soviet Union launched two major science satellites, the Granat astrophysical observatory and the Aktivny Earth physics satellite. Granat's ART-II telescope and French-built Sigma telescope will make measurements of galaxy clusters, X-ray pulsars, and materials surrounding black holes, using star maps developed by the German Rosat. Aktivny will measure the interaction of radio waves with charged particles in the Earth's magnetosphere.

Also in preparation for launch soon after the end of the year, continuing the so-called new "golden age" of scientific space exploration, are the U.S. Hubble Space Telescope (scheduled for a Shuttle launch in March 1990), which is expected to see to the edge of the Universe, Gamma-Ray Observatory (to be launched in June 1990), the European Ulysses solar polar probe (in October 1990), the Upper Atmospheric Research Satellite (in November 1991), the U.S.-France Topex/Poseidon ocean-sensing satellite (in 1992), the abovementioned U.S. Mars Observer (1992), and the multiple-spacecraft cooperative International Solar-Terrestrial Physics program, involving Europe, Japan, and the U.S.

Major 1989 initiatives in the Search for Extraterrestrial

Intelligence (SETI) program included approval of the U.S. Microwave Observing Project, which uses sophisticated multichannel spectrum analyzers and signal detection systems to search in the microwave spectrum for signals from other civilizations, a proposal by the Soviet Union to conduct regular whole-sky patrols using the Samarkand antenna and, possibly, future space-based radiotelescopes, Japanese searches using their new antenna, an Italian proposal to use the new European radiotelescope for SETI, and initiation of a new southern-hemisphere search by the Argentine Institute of Radioastronomy using a copy of Harvard University's META analyzer.

B. Manned Systems

Planning for manned exploration of the Moon and Mars came into focus in 1989 in both the Soviet Union and the United States. The success of Energiya-Buran late in 1988 gave new emphasis to Soviet mission plans requiring heavy-lift launch capability. Budget constraints have delayed implementation of those plans, but have reemphasized the need for international cooperation on costly manned exploration programs.

In the U.S., the conclusions of prior studies by the National Commission on Space, NASA, and others were integrated this year into a group of options documented by NASA's Office of Exploration in a study titled "Beyond Earth's Boundaries." One of these options, establishment of a manned base on the Moon and a subsequent manned outpost on Mars, was adopted formally as a U.S. space goal by President Bush in July 1989, subject to detailed analyses of budgetary and other requirements. As with the USSR,

consideration of conducting these missions in cooperation with other countries is a key element in these analyses. Unfortunately, however, budget for the U.S. "Pathfinder" technology program, created two years ago to begin developing the technologies needed for extended manned space flight beyond low Earth orbit, was again cut by the U.S. Congress to a fraction of the program's needs.

VI. TECHNOLOGY ADVANCEMENT

A. Propulsion

Major 1989 propulsion developments in the U.S. included initiation of the Advanced Solid Rocket Motor development program, testing and evaluation of a new turbopump assembly for the Space Shuttle Main Engine (SSME) with far fewer components, and design definition of two new large liquid-propellant engines for possible use with the Advanced Launch System and the Liquid Rocket Booster: the Space Transportation Main Engine (STME) and the Space Transportation Booster Engine (STBE). The STME is a large hydrogen-oxygen engine in the 250-metric-ton thrust class, for both booster and sustainer applications, designed primarily for reliability rather than incremental performance; the STBE, for use only in first-stage applications, is an oxygen-hydrocarbon engine of about the same size. U.S. propulsion activity also includes storable-propellant systems for the Orbital Maneuvering Vehicle, currently under development, and the still-conceptual Space Transfer Vehicle, as well as arcjet development for stationkeeping use and an experiment on the use of aerobrakes for retrothrust applications. The U.S. also

conducted extensive research and testing on multiple-cycle engines for aerospace plane use.

Japan's primary emphasis in 1989 was on development of the LE-7 hydrogen-oxygen engine for the H-2 launch vehicle. Ground experiments were also conducted, using the H-1's LE-5 oxygen-hydrogen engine, on a long-known but never-developed airbreathing engine concept, the Liquefied Air Cycle Engine (LACE), in which oxygen extracted from air liquefied during early phases of atmospheric flight is used to power the LE-5 later in its trajectory. LACE-equipped liquid-propellant boosters have been proposed to replace the H-2's solid-propellant boosters, based on the claim that they would triple the H-2's payload capability to low Earth orbit.

B. Power

The large-area photovoltaic arrays for Space Station Freedom (6-1/4 kW each), built up of 8 x 8 cm thin silicon cells, underwent preliminary testing in 1989. High-efficiency, low-mass, radiation-tolerant gallium arsenide cells, which reached full-scale mass production in the U.S. and Japan in 1989, are expected to become cost-competitive with silicon during the next few years when present U.S. pilot production on germanium substrate (instead of gallium arsenide) reaches the full-scale production phase.

Progress on solar thermal space power system development accelerated in 1989 to the point at which it was seriously considered for implementation on Phase 1 of Freedom instead of Phase 2, as had originally been planned. It was finally decided,

however, to continue with the original all-photovoltaic plan for Phase 1.

Radioisotope thermoelectric generators, used for over two decades in all outer-planet and other missions where solar energy is not sufficient, demonstrated their capabilities dramatically on Voyager 2's Neptune-Triton flyby. Upgraded RTGs were launched aboard Galileo, and although the mission is a decade later than originally planned, they should perform as expected. The Ulysses solar-polar explorer will also use RTGs when launched next year.

Nuclear reactor power sources Romaschka and Topaz have been used by the USSR for years in military spacecraft, but the newest design of Topaz, which uses thermionic converters to deliver 10-15 kWe, was offered to the U.S. and other countries by the Soviet Union this year for use in civil missions. The U.S. SP-100 space reactor ground-test system, a compact, fast-spectrum lithium-cooled reactor powering advanced thermoelectric converters, is currently scheduled for a 1995 system engineering ground test but has been delayed due to both technical and budget problems. A flight-test version is not expected to fly until the end of the century.

Design and technology advancement continued on the French ERATO reactor, which employs modular 25-kWe Brayton-cycle gas-turbine power conversion units for a maximum capacity of 100 kWe. France and the Soviet Union agreed in 1989 to cooperate on space nuclear reactor power development.

C. Materials

1989 saw a major expansion in the use of composites,

developed originally for high-temperature, lightweight aircraft and spacecraft applications. Future systems such as Hermes and the U.S. aerospace plane are being designed almost wholly around both metal-matrix and nonmetallic composites. Because of the importance of these materials in future high-performance systems, the U.S. took the unprecedented step of forming a consortium of all five aerospace plane contractors to share their materials research efforts.

D. Automation, Robotics, and Teleoperators

Planning for new space-station activities in both East and West has intensified the focus on expert systems, artificial intelligence, and teleoperators to support astronauts and cosmonauts in performing their tasks. The major new development this year was the U.S. award to Martin Marietta for a Flight Telerobotic Servicer (FTS), initially for use in assembling Freedom, but with prospective commercial applications for work in hazardous environments. The current FTS design uses four video cameras, two on its "head" for stereo vision and one on each of its "hands," for close-up views of work pieces. Each of the FTS's two manipulator "arms" has 7 degrees of freedom; the third arm holds the FTS at the work site. Average power consumption is only 750 W.

Another important emerging use of teleoperators is in conducting science experiments in space. Although there is no substitute for an on-site human operator, many relatively simple experiments can be performed by ground-based scientists or technicians using teleoperators. An entire session at the 40th

IAF Congress was devoted to various applications in space "telescience."

E. Space Debris

An exhaustive U.S. study of this long-recognized problem was completed this year, reaffirming the need for better methods and equipment for detecting and tracking debris of all types, and outlining in detail the various approaches for reducing the accretion of debris from future space projects. An essential prerequisite to any rational program on space debris control is international agreement on the elements of that program, as reaffirmed by the U.S. report.

F. Microgravity Research Facilities

The principal constraint on physical-chemical microgravity research aimed at process and product development is the lack of adequate space facilities for conducting the necessary experiments. Current long-term testing is available only in the Soviet Mir, which is limited in research laboratory equipment and suffers from variations in microgravity due to cosmonaut activities and stationkeeping requirements.

To supplement Mir and ESA's Eureca platform to be launched in 1991, new efforts to develop microgravity research facilities include the following:

o A German-led international team of MBB (FRG), GE (USA), Matra (France), and Aeritalia (Italy) initiated a program to develop a cooperative platform, AMICA, for lease by microgravity experimenters. AMICA's design is patterned after Eureca's, with a

2.3 x 4.5-meter payload bay able to carry about 1,000 kg of experiments into orbit.

o The Mikroba balloon-launched microgravity test system developed by OHB System (FRG). Mikroba, which demonstrated its operational readiness in May during a flight test from Kiruna, Sweden, can carry payloads up to 200 kg in its 2 x 0.4-meter bay and provides up to 1 minute of microgravity after being dropped from its peak altitude of 40-45 km. Balloon flights are also planned by OHB-System to flight-test 600-kg Shuttle and Hermes models in the transonic speed range up to Mach 1.2

o The Intospace experiment package Cosima 2, launched this year by the Soviet Soyuz in a recoverable Soviet Resource capsule. The 14-day flight carried experiments for European and Japanese pharmaceutical companies and German and Dutch research institutes. The Cosima 1 crystal-growth experiment was carried by a Chinese capsule in 1988.

o The Soviet space-processing experiment satellite Foton, launched in 1989.

o Signing of a microgravity research protocol by France and the USSR.

o Signing of a cooperative marketing and facility development agreement by Spacehab (USA), Aeritalia (Italy), and Mitsubishi (Japan).

o Termination of consideration by NASA of a Commercially Developed Space Facility for interim use pending availability of Freedom's laboratories.

o Commercial launch of a sounding-rocket payload by USA's Space Services Inc., a new entry in the commercial launch-

services field, for materials processing research by the U.S. Consortium for Materials Development in Space.

o Creation by NASA of 16 Centers for the Commercial Development of Space, many of which are dedicated to microgravity research, the design of microgravity experiments, and the development of microgravity research facilities.

o Continued examination of the role of tethers in microgravity research, experiments, and operations. The first flight experiment, currently scheduled for a January 1991 Shuttle flight, will use a 20-km tether to explore these prospects; a second demonstration being planned by the NASA-Agencia Spaziale Italiano (ASI) tether program partners will use a 100-km tether.

o Initiation by NASA of a Wake Shield facility, a 3-m diameter shield to be towed behind the Shuttle to provide extremely high vacuum environments needed for semiconductor and other materials processing experiments.

A summary of current microgravity facility projects worldwide appears in the accompanying table.

VII. EDUCATION

This year was marked by significant expansion in space-related educational activities, including the following:

o Growth of the International Space University (ISU) in all aspects: student body, faculty, breadth and depth of curricula, and campus facilities. The semester at the University of Strasbourgh in France during the summer was particularly successful, and bodes well for forthcoming semesters and coursework. The eminent Arthur C. Clarke, who first conceived the

geostationary-orbit communications satellite system, was elected Chancellor of ISU in 1989.

o The wide scope of educational activities being developed as part of the International Space Year (ISY), both by individual countries and by international organizations such as the IAF.

o Education conferences associated with both the Voyager Neptune flyby and the Galileo launch.

o Creation and growth of the Challenger Center for science education, dedicated to the memory of the U.S. Challenger crew.

o The Planetary Society's "Together to Mars" program and scholarship program to encourage students to undertake planetary studies.

o The solar sail race sponsored by the AIAA.

o The European Space Information System (ESPRIN) being set up by ESA in Italy.

o The U.S. Satellite Educational Resources Consortium's pilot semester (Spring 1989) and beginning of its demonstration year (September 1989).

VIII. SPACE LAW

Two new national organizations were set up in 1989, the Canadian Space Agency and the German Space Agency (DARA) in FRG. A European Center for Space Law was also created.

The International Institute of Space Law approved a "Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence," which recommends a series of steps that should be taken by an observer who detects a signal of intelligent extraterrestrial origin. Other space law

activities in 1989 focused on the following issues:

- o The particular needs of the developing countries.
- o Space debris and other space environment concerns.
- o Legal status of the geostationary orbit and activities conducted therein.
- o Near-Earth traffic.
- o Verification by satellite and other means for maintaining peaceful use of space.
- o Liability considerations in international space-station agreements.
- o Legal aspects of commercial space activities.

TABLE I: SUMMARY OF ORBITAL FACILITIES CAPABILITIES

Facilities	Developer	μ -g Duration	Estimated Gravity (g) Level	Crew Interaction	Flight Frequency	Year Available (Projected)	Power to Payload	Payload Volume	Maximum Payload Mass
SHUTTLE: EXISTING									
Getaway Specials	NASA	4-7 days*	10^{-3}	Payload bay; Crew has on/off switches only	Up to 50/year (Shuttle)	Operational	Supplied by Experimenter	$0.15m^3$	90kg
MSL	NASA	4-7 days*	10^{-3}	Payload bay; Remote Oper.	5/year (Shuttle)	Operational	1.41kW(Ave) 2.59kW(Peak)	$4.35m^2$ mounting area	926kg
Middeck	NASA	4-7 days*	10^{-3}	Crew-tended	Up to 14/year (Shuttle)	Operational	116W/locker	$.06m^3$ (10 lockers/ mission)	27kg/locker (10 lockers/ mission)
Spacelab (Long Module)	ESA/NASA	4-7 days*	10^{-3}	Crew-tended	1-4/year (Shuttle)	Operational	3.4kW(Ave) 7.7kW(Peak)	$8.07m^3$	4,550kg
SHUTTLE: PROPOSED									
Spacehab	Spacehab McDAC Aeritalia	4-7 days*	10^{-3}	Crew-tended	1-3/year (Shuttle)	1991	3.2kW(Ave) 5.7k(Peak)	$4.6m^3$ (59 lockers)	1,360kg
ISF (FACILITY MODULE)	SSI Partners	years	10^{-5}-10^{-6}	Crew-tended in attached mode Free-flyer cap.	3/year revisits Shuttle	1993	7kW(Ave) 10kW(Peak) (Free flyer)	$9.50m^3$	2,950-6,220kg by orbiter
EURECA/AMICA	ESA	6 months	10^{-5}-10^{-7}	Free-flyer; Shuttle deploy & return	3/year (Shuttle)	1991	1kW(Ave) 1.5kW(Peak)	$8.50m^3$	1,000kg
JAPANESE FREE-FLYER	Japan	6 months	N/A	Free-flyer; Shuttle return	N/A	1993	N/A	N/A	N/A
LESSERCRAFT	Fairchild	years	N/A	Free-flyer;	N/A	In	1-7kW(Ave)	N/A	6,800kg
PHOTON	USSR	14-30 dys	10^{-5}	Untended	N/A	Operational	400W(Ave)	$4.7m^3$	500kg
FSW	China	6-15 days	N/A	Untended Free-flyer	N/A	Operational	100W	N/A	300kg
SPACE STATION MIR	USSR	years	10^{-3}-10^{-5}	Crew-tended	Cont. Operation	Operational	10w total pwr. should	$90m^3$ to. volume	N/A
SPACE STATION FREEDOM	NASA, ESA Japan, Can.	years	10^{-5}-10^{-6}	Crew-tended	Cont. Operation	1996	45kw total	$60m^3$ to. usable Lab. vol. (120 std. racks)	68,200kg

*Can be extended with EDO capabilities.

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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

UNITED NATIONS ACTIVITIES RELATING TO SPACE APPLICATIONS

Report of the Secretariat in response to the request of the Working Group of the Whole to evaluate the implementation of the recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space

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INTRODUCTION

1. The Scientific and Technical Sub-Committee of the Committee on the Peaceful Uses of Outer Space (COPUOS), at its twenty-sixth session, in 1989, re-established, for its third session, the Working Group of the Whole to Evaluate the Implementation of the Recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82). The report of the Working Group of the Whole (A/AC.105/429, annex II), which was adopted by the Scientific and Technical Sub-Committee, contained a number of recommendations on which actions were to be taken by the Outer Space Affairs Division. Those recommendations were endorsed by the Committee on the Peaceful Uses of Outer Space in its report, 1/ which was subsequently endorsed by the General Assembly in its resolution 44/46 of 8 December 1989.

2. The present report was prepared by the Outer Space Affairs Division in accordance with the requests contained in paragraphs 4 to 6 of the report of the Working Group of the Whole.

I. FELLOWSHIP PROGRAMME FOR IN-DEPTH EDUCATION AND TRAINING

3. In paragraph 5 (d) of its report, the Working Group recommended that:

> "the United Nations should organize a fellowship programme through which selected graduates or post-graduates from developing countries should get in-depth, long-term exposure to space technology itself as well as to its applications; it is also desirable to encourage the availability of opportunities for such exposures on other bilateral and multilateral bases outside the United Nations system."

4. At present, the United Nations Programme on Space Applications, hereafter known as "the Programme", administers annually 40 long-term fellowships for in-depth training in basic space sciences, remote sensing, satellite communications and satellite meteorology. The duration of the training periods of these fellowships varies from 10 months to 6 years. The fellowships provide opportunities for obtaining either: (a) a Master's degree in engineering sciences, (b) post-graduate professional experience or (c) post-doctoral research experience.

5. A number of these fellowship awards are being offered in various areas of space technology, as follows:

General areas (total fellowships)	Specific field/ title of fellowship	Offering Government/ organization	No. of fellowships offered
Basic space sciences (8)	Astronomy, astrophysics and cosmology	German Dem. Rep.	1
	Satellite observation techniques	German Dem. Rep.	1
	S. P. Korolev awards for studies in scientific instrument manufacturing	USSR	2
	Ya. B. Zeldovich awards for studies in theoretical and experimental physics	USSR	2
	M. V. Keldish award for studies in systems and methods of space information processing	USSR	1
	K. E. Tsiolkovskii award for research in uses of space technology for Earth rotation and lithosphere plates movement	USSR	1
Remote sensing (27)	Remote sensing technology	Brazil	10
	Remote sensing information systems	ESA	1
	Remote sensing applications	German Dem. Rep.	1
	Geodesy, cartography and aerial photography	USSR	15
Satellite communications (4)	Microwave technology	Austria	2
	Communications engineering	ESA	1
	Telecommunications	ESA	1
Satellite meteorology (1)	Meteorology	ESA	1

6. The manner in which these fellowship awards were administered by the Programme in 1989 is detailed in annex II to the current report of the United Nations Expert on Space Applications to the Scientific and Technical Sub-Committee (A/AC.105/446).

II. METHODOLOGY FOR THE AWARD OF LONG-TERM FELLOWSHIPS

7. Paragraph 4 (a) of the report of the Working Group directed that:

> "the Division should also prepare a report containing an evaluation of the methodology for granting fellowships. Likewise, the Division should request the States beneficiaries of such fellowships to carry out an evaluation of the benefits derived from such training programmes."

8. It should be noted that all long-term fellowships offered through the Programme are advertised at least eight months in advance of the date on which each fellowship is scheduled to begin. Information on available fellowships for each year is forwarded both through the offices of the Resident Representatives of the United Nations Development Programme (UNDP) in the individual countries and through the Member States' permanent missions to the United Nations. Specialized government institutions and centres of higher education in the developing countries are also informed directly of the availability of these fellowships.

9. Beginning in 1988, the methodology for awarding long-term fellowships was streamlined. In this connection, a guidebook containing descriptions of all fellowship awards has been developed; it also contains a standard set of nomination documents (i.e., letter of transmission, application form, referee report and medical clearance forms). In soliciting nominations, the following documents are distributed to Member States:

(i) A guidebook on fellowships and training opportunities offered within the framework of the United Nations Space Applications Programme (SAP/88/001), containing a detailed description of the programme of each pre-1988 fellowship offer, the necessary prerequisites for each award and the administrative procedures to be followed; details on additional fellowships established after 1988 are described in an annex;

(ii) An application and instruction booklet (SAP/88/002) containing fellowship nomination forms along with instructions on how they should be completed and endorsed by the candidate's Government/institution;

(iii) An information sheet containing the specific details of each fellowship programme.

10. All completed nominations received by the deadline established for each fellowship are analysed taking into account the adequacy of each candidate's academic background in relation to the field of the fellowship, fluency in the language of instruction and the health status. Other factors that are considered include the opportunities for utilizing the knowledge acquired upon the candidate's return to his/her country, as attested to by the immediate supervisor and two other

referees, and the candidate's age. The Programme analyses the contents of the documents submitted by all the applicants. These documents and the Programme's recommendations on the selection of suitable candidates are subsequently transmitted to the Government/agency offering the fellowship for its review and concurrence.

11. The current methodology has reduced both the time and costs of advertising the long-term fellowships and provides Member States with an overview of the total number and specific areas in which fellowships will be awarded for the next one-year period.

12. Furthermore, the Programme's experience to date has been that the qualifications of potential candidates vis-à-vis the prerequisites for each fellowship and the expediency with which the nominations are dispatched to the United Nations vary from country to country. Contributing to these problems is the mischanneling, at the local level, of information provided by the United Nations. In addition, lengthy internal procedures within a significant number of local institutions often delay the nomination process.

13. The Programme on Space Applications has sent an evaluation questionnaire to the Governments of all individuals who were recipients of long-term fellowship awards since 1983, requesting their evaluation of the benefits derived from the participation of their scientists in the fellowship programme. An analysis of the replies received by 31 March 1990 will be presented in a report to be distributed to Member States during the thirty-third session of COPUOS, in June 1990.

III. EDUCATION, TRAINING, RESEARCH AND FELLOWSHIP OPPORTUNITIES AVAILABLE THROUGH MEMBER STATES AND INTERNATIONAL ORGANIZATIONS

14. Through paragraph 4 (k) of its report, the Working Group directed that:

> "on the basis of the information provided by the States, the Division should prepare on a regular basis an updated report on the resources and technological capabilities of the States in the fields of space activities, including education, training, research and fellowship opportunities, for the promotion of co-operation in the peaceful uses of outer space."

15. In this respect, the Division has requested such information from Member States, the specialized agencies and other bodies of the United Nations system and from other international agencies. The replies have been analysed and summarized in a document titled "Education, training, research and fellowship opportunities in space science and technology and its applications - a directory" (A/AC.105/432), which was issued in 1989 and distributed to Member States during the thirty-second session of COPUOS, in 1989. This information will be updated as appropriate.

IV. ROSTER OF EXPERTS IN SPACE SCIENCE AND TECHNOLOGY

16. In paragraph 4 (e) of its report, the Working Group also recommended that:

> "in order to promote better access to and experiences in higher education of space-related subjects, the United Nations should, upon request, arrange for the provision of consultancy of experts from the developed and developing countries in the preparation of an integrated national plan of action for initiating, strengthening or reorienting an appropriate programme which should be in conformity with other programmes of national development. The Outer Space Affairs Division should compile periodically a list of experts in space technology and applications to facilitate the exchange of consultants at the international level."

17. In this connection, the Secretary-General has sent a note verbale to Member States requesting that they provide a list of their experts as indicated in the above paragraph. A summary of the replies received by 31 March 1990 will be presented in a report to be distributed to Member States during the thirty-third session of COPUOS, in June 1990.

V. PARTICIPATION OF THE UNITED NATIONS SYSTEM IN THE IMPLEMENTATION OF THE UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS

18. In paragraph 4 (f) of its report, the Working Group recommended that:

> "in formulating co-operative programmes and projects, intensive participation of international and regional financial and development institutions should be encouraged by the United Nations. In this connection, the Secretariat should prepare a report on the arrangements it has made with other organs, bodies and organizations of the United Nations system in order to utilize fully the available resources and to secure financial support from other sources for continued implementation of the United Nations Programme on Space Applications."

A. Short-term activities

19. In connection with the above request, it should be noted that for the workshops/courses/seminars that it organizes it is the policy of the Space Applications Programme to invite the specialized agencies of the United Nations to co-sponsor those activities that fall within their respective areas of competence. Similar invitations are usually extended to the economic commissions of the regions in which the activities are held. The co-sponsoring organizations share the costs associated with the conduct of those activities. The arrangements regarding such co-operation are arrived at during the annual inter-agency meetings on outer space activities that serve to co-ordinate the efforts of the United Nations system, as well as during the annual sessions of COPUOS and its Scientific and Technical Sub-Committee.

20. Examples of such co-operation include the five training courses conducted between 1983 and 1989 on applications of remote sensing and satellite meteorology to agrometeorology and hydrology, and co-sponsored by the United Nations, the Food and Agriculture Organization of the United Nations (FAO), the World Meteorological Organization (WMO) and ESA, as well as the ongoing series of training courses on remote sensing applications co-sponsored by the United Nations, FAO and the Government of Italy (the fourteenth in the series was held in 1989).

B. Long-term and indigenous capability-building activities

21. Regarding the other elements of its mandate, the Programme continuously seeks material and financial support from other entities of the United Nations system. In particular, in co-operation with the Economic Commission for Africa (ECA), the Programme developed a draft project proposal that could enhance the capabilities of Member States on the Atlantic coast of Africa to benefit from the applications of remote sensing and satellite meteorology to marine resources and coastal management. The proposal was sent to all relevant entities of the United Nations system and to ESA for their comments and possible participation.

22. A revised project proposal that benefited from the comments received from the above entities was presented to the UNDP Regional Bureau for Africa. Subsequent negotiations between the Programme and the Bureau led to the development of a preparatory assistance project document. The first phase of the project included the organization of a meeting of experts in 1989 (held at Maspalomas, Gran Canaria, Spain) with the following objectives: (a) to analyse the role of space science and technology in the assessment, evaluation and management of marine resources and of the coastal environment; (b) to focus on mechanisms needed to provide regional atlases, charts and maps and other reference documentation on coastal, territorial and exclusive economic zones of the Atlantic coastline; and (c) to supply elements that could be used to prepare a final project document on regional co-operation in those areas. The second phase of the project, which is under preparation, would include a follow-up mission to the marine and oceanographic institutions in up to five countries of the region, by a team of experts with the following objectives: (a) to evaluate the existing infrastructure; (b) to determine the degree of commitment of the institutions/Governments of those countries to an eventual regional project; (c) to make recommendations on the possible location(s) of a host institution for a regional project on remote sensing and satellite meteorology applications to marine resources and coastal environment; and (d) to draft the above-mentioned final project document based on the recommendations of the meeting of experts held at Maspalomas and the findings during the mission, to be presented to potential donors. While funding for the two phases of the preparatory assistance project is being provided by UNDP, funding for implementing the main project would have to be sought from both UNDP and external sources.

23. Following the recommendations of the two meetings of experts on regional co-operation in space science and technology among Member States of the Indian Ocean Marine Affairs Co-operation (IOMAC) region organized in 1986 (Colombo) and 1989 (Karachi), consultations are being held with UNDP to obtain its support for a marine/space applications project and a regional information service project for

the benefit of IOMAC Member States. In this connection, agreements have been reached on three remote sensing pilot projects which will be carried out in the region as part of IOMAC's activities; these are being financed by UNDP.

24. The Space Applications Programme has initiated exploratory consultations with UNDP regarding the possibility of UNDP providing financial support, on a regular basis, for the activities of the Programme, particularly those aimed at developing scientific and technical capabilities in space-related areas at the local level. The Programme will inform the Scientific and Technical Sub-Committee of the outcome of these consultations.

VI. PROMOTION OF SPACE ACTIVITIES CONDUCTED BY SCIENTIFIC ORGANIZATIONS

25. In paragraph 4 (j) of its report, the Working Group recommended that:

> "encouragement should be given to non-governmental organizations which, by means of conferences, publications and other activities including the holding of symposia and meetings devoted to special topics, could help to integrate regional and interregional efforts in order to facilitate and co-ordinate the space activities of scientific organizations. The United Nations should strengthen its co-operation with them, as part of its commitment to assisting developing countries attain the benefits of space technology. Efforts should also be made by the United Nations to seek the co-operation of other international and regional bodies specialized in space activities. In this connection, the Outer Space Affairs Division should submit a report at the next session of the Scientific and Technical Sub-Committee."

26. With reference to the above request, the Outer Space Affairs Division has maintained close and fruitful relationships with the International Astronautical Federation (IAF) and with the Committee on Space Research (COSPAR); it has collaborated with them in organizing symposia and has conducted studies on topics requested by COPUOS for presentation to its Scientific and Technical Sub-Committee. Since 1982, the Programme on Space Applications has co-sponsorsed a workshop on specific topics of interest to developing countries at each of COSPAR's plenary meetings. The Programme contributes to the plenary meetings both through substantive presentations at the workshops and through the sponsorship of three to five participants from developing countries. In addition, the Programme has been providing support to three to four participants from developing countries to recent IAF congresses, which now include a special-event session devoted to subjects of interest to developing countries (e.g., desertification, 1988; flood management, 1989; deforestation, 1990).

27. More recently, the Programme has enhanced its co-operation efforts with other non-governmental organizations, notably the International Society for Photogrammetry and Remote Sensing (ISPRS) and the Society of Latin American Professionals Specializing in Remote Sensing (SELPER). In particular, plans are under way to prepare and publish, in co-operation with ISPRS, a directory of sources of scientific publications and literature with particular emphasis on

remote sensing and photogrammetry. The Programme also sponsors the participation of scientists from developing countries in some of the congresses and symposia of ISPRS. Similarly, the Programme sponsors the participation of Latin American specialists in the symposia organized by SELPER and on a regular basis invites it to contribute to the activities organized by the Programme in the Economic Commission for Latin America and the Caribbean (ECLAC) region.

VII. NATIONAL AND REGIONAL DATA BASES AND AN INTERNATIONAL SPACE INFORMATION SYSTEM

28. In paragraph 5 (c) of its report, the Working Group recommended the following:

> "Taking into account paragraph 8 (b) of General Assembly resolution 43/56, on the strengthening of data banks at the national and regional levels and the establishment of an international space information service, the Working Group requested the Outer Space Affairs Division to convene, if other priorities permit, a meeting of governmental experts representing developed and developing countries to examine in detail the most cost-effective and efficient ways for the implementation of this recommendation."

29. With reference to the above request, it should be noted that due to limited financial resources it was not possible for the Division to organize the proposed governmental meeting of experts. However, this item is addressed in the programme of all seminars, workshops and training courses conducted under the auspices of the Programme on Space Applications. For instance, in 1989 the issue was addressed at the meeting held at Dundee, United Kingdom (see A/AC.105/438) and the workshop held at Karachi, Pakistan (see A/AC.105/439).

Notes

1/ Official Records of the General Assembly, Forty-fourth Session, Supplement No. 20 (A/44/20).

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COMMITTEE ON THE PEACEFUL USES
OF OUTER SPACE

REPORT OF THE INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION

Note by the Secretariat

The report 1/ of the International Telecommunications Satellite Organization (INTELSAT), covering the period from 1 April 1988 to 31 March 1989, has been submitted for the attention of the Committee. It is being made available by INTELSAT at this time in English, French and Spanish only.

Notes

1/ In view of the limited number of copies received, the report is distributed to participants only.

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